Potential Future Directions for the Division of Discovery Science and Technology

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Scope of Scientific Programs
Division of Discovery Science and Technology

- Advanced Biomaterials
- Bioinformatics
- Biomechanics and rehabilitation engineering
- Drug and gene delivery systems and devices
- Image processing, displays, and perception
- Mathematical models and computational algorithms
- Medical devices & implant science
- Platform technologies (lab-on-a-chip)
- Remote diagnosis and therapy (telehealth)
- Sensors
- Surgical tools and techniques
- Tissue engineering

Focus Areas for Potential Future Directions

- Materials Technologies
- Sensors and Lab-on-a-chip
- Tissue Engineering
- Bioinformatics and Computational Biology

Materials Technologies

- Research and development of new or novel biomaterials that can be used for a broad spectrum of biomedical applications such as implantable medical devices, drug and gene delivery, and biosensors.

- Research on the design, synthesis, characterization, processing and manufacturing of these materials as well as the design and development of devices constructed of these materials and their clinical performance.

Materials Technologies
Current Portfolio

Scientific Subcategory	# active grants	Total Costs (million $)
Novel Biomaterials	33	8.6
Implantable Sensors	10	2.4
Drug/Gene Delivery	35	9.2
Medical Devices / Implant Science	7	3.3
Total	**85**	**$23.5 M**

Potential Future Directions
Materials Technologies

1. **Promote the development of techniques to improve interfacial properties of biomaterials that have potential impact across many application areas.**
   - **Background:** The safety and efficacy of implanted devices is limited by surface problems such as the potential for thrombogenicity and biofouling.
   - **Direction:** Promote the development of new nanoscale materials and surface characterization techniques to produce truly biocompatible biomaterials.

2. **Leverage emerging nanotechnologies to develop rationally designed drug and gene delivery vehicles**.
   - **Background**: The effectiveness of current drugs can be improved by targeted delivery to specific cells and tissues. The clinical application of gene therapy requires delivery vehicles with high transfection rates and minimal side effects.
   - **Direction:** Promote the development of new self-assembly and chemical synthetic methods to produce nanostructured delivery vehicles with robust cell or nuclear targeting, imaging, and delivery capabilities.

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Sensors and Lab-on-a-Chip

Sensors

- Research and development of novel signal transduction approaches, molecular recognition, biocompatibility, signal processing, fabrication technologies, actuators, and power sources.

- Application areas include biomedical research, in vitro diagnostics, biodefense, noninvasive monitoring, and implantable devices.

Lab-on-a-chip

- Research and development of BioMEMS, microfluidics and nanoscale technologies; micro-total analysis systems, arrays, and biochips.

- Application areas include biomedical research, clinical laboratory diagnostics, biodefense, high-throughput screening, drug delivery, tissue engineering, and implantable devices.

Sensors and Lab-on-a-Chip Current Portfolio

Scientific Subcategory	# Active Grants	Total Costs (million $)
Enabling Technologies	39	9.5
Clinical Lab Diagnostics	18	7
Noninvasive Monitoring	7	2
Biodefense	8	1.5
Drug Discovery/HTS	3	1
Basic Biology	4	0.7
Total	79	$22 M

Potential Future Directions
Sensors and Lab-on-a-chip Technologies

1. **Support the development of integrated sensor and lab-on-a-chip devices for point-of-care testing.**

   Background: Current emphasis is on development of technology components and testing on ideal (not real) samples.

   Direction: Address issues associated with component integration and push toward use of complex biological samples for device testing to realize practical applications.

2. **Strengthen the enabling technology development program area, with an emphasis on high-risk/high-impact research areas such as nanotechnology.**

   Background: Ongoing need for improvements in sensitivity, specificity, multiplexing, and throughput in sensor and lab-on-a-chip devices.

   Direction: Encourage the development of novel technologies that overcome current limitations and enable new applications.

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Tissue Engineering

- Enabling technologies
- Engineering methods and design
- Biomolecules and Cells
- Biomaterial scaffolds
- Tissue-engineered therapies

Tissue Engineering Program Current Portfolio

Scientific Subcategory	# of Active Grants	Total Costs (million $)
Biomolecules and Cells	10	3.4
Scaffold Development / Tissue-engineered therapies	24	6.6
Enabling Technologies	10	2.8
Total	**44**	**$12.8 M**

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Potential Future Directions Tissue Engineering

1. **Development of enabling technologies for tissue engineering with an emphasis on: 1) real-time, non-destructive tools to assess function; 2) computer-aided tissue engineering, and; 3) bioreactor and tissue preservation technologies.**

   Background: Tools and technologies currently available are limited.

   Direction: Lead the development of enabling technologies that are crucial in aiding and translating tissue engineering applications to improve human health

2. **Development of engineered 3D human tissue model systems for basic and clinical research as well as drug discovery and development.**

   Background: Inaccuracies and high costs of animal studies to predict human response, safety and efficacy.

   Direction: Promote the development of engineered 3D human tissue model systems that closely mimic the complex environment and interaction of humans organ systems.

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Bioinformatics and Computational Biology

- Bioinformatics

  Research, development, or application of computational tools and approaches for expanding the use of biological, medical, behavioral or health data, including those to acquire, store, organize, archive, analyze, or visualize such data.

- Computational Biology

  The development and application of data-analytical and theoretical methods, mathematical modeling and computational simulation techniques to the study of biological, behavioral, and social systems.

Bioinformatics and Computational Biology Current Portfolio

Scientific Sub-Categories	Number of Active Grants	Total Costs (million $)
BIOINFORMATICS	**75**	**26.3**
Computational Tools	11	11.3
Atlases and Visualization Tools	9	2.4
Surgical Tools	4	0.8
Telehealth	7	1.5
Rehabilitation Engineering	7	10.3
COMPUTATIONAL BIOLOGY	**36**	**11.7**
Image Processing and Evaluation	9	8.7
Models and Methods	9	3.0
Total	**112**	**$38.0 M**

Potential Future Directions

Bioinformatics and Computational Biology

Promote the development and integration of computational tools and platforms for all scientific program areas supported by the NIBIB.

1. **Promote multiscale modeling in biomedical systems.**

2. **Promote intelligent systems design and smart modeling, analysis and simulation methods that automatically adapt to changing conditions.**

Background: The long-term, high risk goal for the NIH Roadmap for Bioinformatics and Computational Biology is to "Deploy a rigorous biomedical computing environment to analyze, model, understand, and predict dynamic and complex biomedical systems across scales and to integrate data and knowledge at all levels of organization"

Direction: Analysis of the current NIBIB portfolio identifies emerging needs and opportunities in developing a rigorous biomedical computing environment. The institute is ideally suited to carry out this goal through the above potential future directions.

Summary of DDST Potential Future Directions

1. New techniques to improve interfacial properties of biomaterials.
2. Nanotechnologies to design drug and gene delivery vehicles.
3. Sensor and lab-on-a-chip devices for point-of-care testing.
4. Novel sensing technologies from high-risk/high-impact research areas such as nanotechnology to overcome current limitations.
5. Enabling technologies for tissue engineering.
6. Development of engineered 3D human tissue model systems for drug discovery and development.
7. Multiscale modeling in biomedical systems.
8. Intelligent systems design and smart modeling, analysis and simulation methods across several application areas.